

Bark from southern pine may find use as fuel

Bark now burned as waste could help supply expanding energy requirements; technology and economics indicate the feasibility of burning southern pine bark to generate steam in electric utility plants

By PETER KOCH and J.F. MULLEN

BARK FROM SOUTHERN PINE TREES has at present little economic value; huge quantities are burned in waste incinerators without thought of recovering energy. Annual consumption of southern pine wood is expected to rise to 7 billion cubic feet or more by the year 2000; accompanying this will be at least 20 million tons of bark if the bark is half water by weight (10 million tons oven-dry). Because of national concern over air pollution, it is likely that the practice of incinerating bark will be curtailed or discontinued.

Bark finds its way into a number of industrial products and these uses will increase, but probably not very fast. By present lights, the most promising way of disposing of large volumes of bark is to make fuel of it. Some wood-using plants currently burn bark to generate their own electricity, but the equipment investment is so heavy that all but the biggest firms find it cheaper to purchase power. Large electrical generating plants, with their huge and reasonably constant demands for fuel, may be able to burn bark economically.

Through a literature review and some laboratory work, the Southern Forest Experiment Station at Pineville, La., has assembled limited data on the feasibility of burning southern pine bark to generate steam in utility plants.

Bark analysis

Analysis of a small sample from the four major southern pine species showed that oven-dry bark is comprised of the following constituents in

approximately the percentages (by weight) indicated: hydrogen 5.5, carbon 56.5, nitrogen 0.4, oxygen 37.0, and ash 0.6. This same oven-dry bark consisted of 66% volatile matter, 0.6% ash, and 33.4% fixed carbon.

Southern pine bark contains no sulfur. The absence of sulfur compounds in the stack gases of a boiler would be an advantage in areas under stringent pollution regulations.

The bark typically contains considerable moisture. In living trees the moisture content averages close to 70% of the dry weight of the bark. Storage of logs and bolts under water sprays, or wetting of piles by rain, probably raises this value. For present purposes, it can be assumed that bark will have 100% moisture content. That is, a pound of wet bark may be half water and half dry matter.

Other tests at Pineville showed that southern pine bark has a heat of combustion of about 8,900 British thermal units (btu) per oven-dry pound, or about 3½% more than the heat content of stemwood (about 8,600 btu per oven-dry pound).

If the bark averages half water by weight, the heat content of a pound is only 4,450 btu. Since energy is lost in evaporating the water, changing the hydrogen content of bark to water during combustion, and discharging hot flue gases to the atmosphere, the usable heat from a pound of wet bark is at best about 70% of 4,450 btu, or 3,115 btu.

Technology of burning bark

Technology is available to build bark-fueled plants to generate electric power, and several are operating successfully. Industrial boilers fueled with southern pine bark have been designed to produce predicted steam flows in

the range of 50,000 to 1,000,000 lbs/hr. Gauge pressure and temperature vary from 150 psi at 520° F. to 1,335 psi at 958° F. or higher. For the large units, fuel consumption may be 200 tons of wet bark per hour. If properly designed, these steam generators require little manpower for operation and do not contaminate atmosphere, land, or water.

For efficient burning, the bark is reduced to particles of the smallest size practical—preferably ¼ inch or smaller—and metered into the furnace on high-pressure air streams. The bark is injected at least 8 feet—and preferably 16 feet—above the grate, so that most of it is burned before it reaches the grate. The system is analogous to suspension firing of pulverized coal.

If moist bark (half water by weight) has a heat of combustion of 8,900/2 = 4,450 btu/lb, and if the boiler is designed to add 1,100 btu/lb to the water and convert it to high-pressure, high-temperature steam, then the efficiency should be about 70%. Under these conditions, about 2.83 lbs of steam can be generated from each pound of moist bark, i.e., $(4,450)(0.70) \div 1,100$. About 10,000 kw of electrical power can be generated from 100,000 lbs/hr of such steam, and to produce that amount of steam would require nearly 20 tons of moist bark per hour.

Fly ash, the fine particles of ash carried out of the stack by flue gases, may contain highly visible particulate charcoal or char in addition to less visible mineral ash. A typical sieve analysis of char carried by flue gas entering the dust collector of a boiler fired with southern pine bark is shown in the table.

This charcoal results from incomplete combustion. Because southern

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Size of mesh (Openings per lineal inch)	Retention on sieve (Percent)	Cumulative retention (Percent)
20	44	44
30	6	50
40	4	54
80	11	65
100	3	68
200	8	76
325	9	85
325	15 (goes thru sieve)	100

pine bark has about 10 to 13% less volatile matter than wood, it also tends to have a correspondingly greater fixed carbon content and hence to produce more char.

If furnace temperatures are high, fuel particles are small, oxygen supply is ample, and overfire air is turbulent, the amount of char leaving the combustion chamber will be held to a minimum. What does enter the flue gases can be cleaned by mechanical or electrostatic devices. Either will do a good job; a combination of the two types is most effective, though most costly.

Byproducts from bark combustion

Theoretically, about 730 lbs of air are required to burn 225 lbs of moist bark. This quantity of bark will yield 1 million btu of heat. The resulting flue gas will be comprised of nitrogen, carbon dioxide, and water vapor.

If the input (no excess air) comprises 225 lbs of fuel, 730 lbs of dry air, and 9.5 lbs of water vapor in the combustion air for a total of about 964 lbs, the output should be heat plus 561 lbs of nitrogen, 233 lbs of carbon dioxide, 169 lbs of water vapor, and 0.7 lb of ash.

When analyzed according to Designation 271-58 of the American Society for Testing and Materials, a limited sample of southern pine bark ash was found to contain about 27% CaO, 21% Al₂O₃, 19% sand (SiO₂), 9% K₂O, 6% SO₃, 5% MgO, 4% P₂O₅, 3% Na₂O, 1% Fe₂O₃, and 5% other material.

If bark ash is treated with water, the potassium compounds dissolve and can be separated from the remaining solids; on evaporation of the solution, potash is recovered.

Ash from coal-fired plants is increasingly utilized in mixes yielding high-strength concrete; a lightweight fraction of the ash (floatable on water) has been shown suitable for the manufacture of high-grade refractories. It is likely that ash from bark can be similarly marketed.

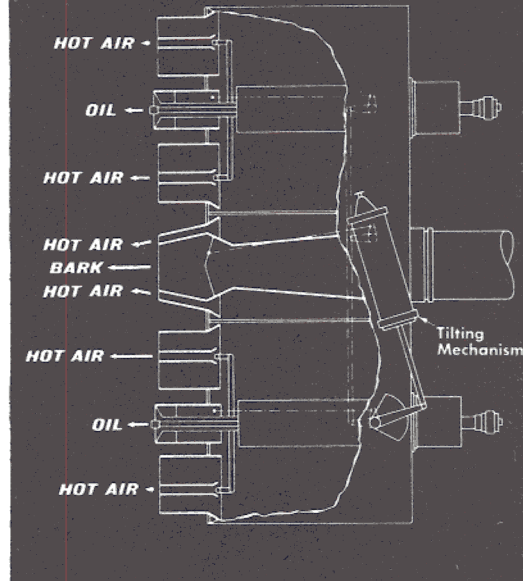
Economics of bark-fired power plants

Fossil fuels, with which bark must compete, can be burned more efficiently than bark and have higher heats of combustion, but cost more per ton (see table). To determine the delivered price at which bark is competitive with the fossil fuels, the fuel cost to generate 1,000 lbs of steam can be calculated from the data in table by assuming that 1,100 btu (usable) are required to generate 1 lb of steam. A delivered price of about \$2 per green ton of bark (half water) appears to be competitive. To be directly equivalent in price to coal, green bark would have to sell for \$1.96 per green ton. The equivalent to oil would be \$2.18, and to gas \$2.45.

Since bark-burning furnaces are larger than oil- or gas-fired units, they cost more to build; because of material-handling equipment, coal-fired boilers cost more than oil-fired units. The approximate relative construction costs (installed) are subject to considerable variation according to steam generating capacity and manner of assembly, i.e., whether shop-assembled or field-erected.

Primary fuels	Relative cost of steam generator
Gas only	1.0
Oil only	1.2
Coal only	1.8
Coal and oil	2.0
Bark only	2.2
Oil and bark	2.4

A bark price of \$2 per green ton (delivered into the fuel pile) permits only minimal transportation charges. Bark from pine-using mills would probably be conveyed into open-top freight cars or motor vans and delivered to power generating plants for bulk discharge into outdoor fuel piles. The delivery system would be closely



Burner assembly for simultaneous or solo injection of bark and oil (or gas). Hot air is introduced in a jet around each fuel jet. Fuel nozzles (with accompanying air jets) can be tilted vertically to alter trajectory for desired distribution of fuel in the furnace. Normally, one burner assembly is located at each of four corners of rectangular furnace. (Drawing from Combustion Engineering Inc.)

comparable to that now used to convey pulp chips from sawmills to pulp mills. Haul distances would necessarily be short.

While revenue to the mill operator from sale of bark would be small, the use of bark as a fuel for utility plants would solve the disposal problem without contributing greatly to air pollution; moreover, such use would promote conservation of fossil fuel. The 20 million tons of green southern pine bark expected to accrue annually by the year 2000 would be sufficient to fuel 12 generating plants, each with a capacity of 1 million lbs/hr of steam (1,000° F.). In total, these 12 plants could supply the present electrical demands of the cities of Savannah, Mobile, and Pensacola. ■

Comparison of fuel values of fossil fuels and southern pine bark					
Fuel	Efficiency (percent)	Heat of combustion as fired (million btu per ton)	Delivered cost* (per million btu)**	Input to generate 1,000 lbs of steam Heat (million btu)	Fuel cost
Bituminous coal	85.0	27.0	\$0.28	1.29	\$0.36
No. 6 oil	82.5	36.0	.30	1.33	.40
Natural gas	77.8	37.1	.32	1.41	.45
Wet bark (half water)	66.5	8.9	.22	1.65	.36

*As of spring 1970; subject to variation according to location.
**Values for oil and gas converted from price per barrel and price per cubic foot.